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MET 330

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HW 1

Chapter 1

1.48 A coining press is used to produce commemorative coins with the likenesses of all the U.S. presidents. The coining process requires a force of 18000 lb. The hydraulic cylinder has a diameter of 2.50 in. Compute the required oil pressure.

1.58 Compute the pressure change required to cause a decrease in the volume of mercury by 1.00 percent. Express the result in both psi and MPa.

1.63 A measure of the stiffness of a linear actuator system is the amount of force required to cause a certain linear deflection. For an actuator that has an inside diameter of 0.50 in and a length of 42.0 in and that is filled with machine oil, compute the stiffness in lb/in.

1.76 In the United States, hamburger and other meats are sold by the pound. Assuming that this is 1.00-lb force, compute the mass in slugs, the mass in kg, and the weight in N.

1.92 A cylindrical container is 150 mm in diameter and weighs 2.25 N when empty. When filled to a depth of 200 mm with a certain oil, it weighs 35.4 N. Calculate the specific gravity of the oil.

1.107 Alcohol has a specific gravity of 0.79. Calculate its density in both slugs/ft^3 and g/cm^3.

Chapter 2

2.17 Give four examples of the types of fluids that are non-Newtonian.

2.18 Using appendix D, give the value of the viscosity for water at 40˚C.

2.27 Using appendix D, give the value of the viscosity for hydrogen at 40˚F.

2.35 Using appendix D, give the value of the viscosity for SAE 30 oil at 210 ˚F.

2.61 In a falling-ball viscometer, a steel ball 1.6 mm in diameter is allowed to fall freely in a heavy fuel oil having a specific gravity of 0.94. Steel weighs 77 kN/m^3. If the ball is observed to fall 250 mm in 10.4 s, calculate the viscosity of the oil.

1.48

GIVEN: $F = 18000$ LB
$d = 2.5$ IN
AREA OF A CYLINDER $= \frac{\pi}{4} \cdot D^2$

SOLUTION:
$$A = \frac{\pi}{4} \cdot D^2 = \frac{\pi}{4}(2.5 \text{ IN})^2 = 4.909 \text{ IN}^2$$
$$P = \frac{F}{A} = \frac{18000 \text{ LB}}{4.909 \text{ IN}^2} = \boxed{3667 \text{ LB/IN}^2}$$

1.58

GIVEN: VOLUME OF MERCURY DECREASED BY 1.00 %.

SOLUTION:

BULK MODULUS EQ: $E = -\frac{\Delta P}{\frac{\Delta V}{V}} \Rightarrow \Delta P = -E\left(\frac{\Delta V}{V}\right)$

FROM TABLE 1.3, $E = 3590000$ PSI OR 24750 MPa

$$\Delta P = -3590000 \text{ PSI}\left(\frac{-1}{100}\right) = \boxed{35900 \text{ PSI}}$$
$$\Delta P = -24750 \text{ MPa}\left(\frac{-1}{100}\right) = \boxed{247.5 \text{ MPa}}$$

1.63

GIVEN: $D = 0.50$ IN
$L = 42.0$ IN
$E = 189000$ PSI (TABLE 1.3)

SOLUTION: FIND STIFFNESS OF ACTUATOR
STIFFNESS $= \frac{F}{L} = \frac{EA}{L}$ WHERE $A = \frac{\pi}{4}(0.5 \text{ IN})^2 = 0.1963 \text{ IN}^2$
$$\text{STIFFNESS} = \frac{(189000 \text{ PSI})(0.1963 \text{ IN}^2)}{42.0 \text{ IN}} = \boxed{883.35 \text{ LB/IN}}$$

1.76

GIVEN: 1.00 LBF

SOLUTION: CONVERT TO SLUGS, KG, AND N

$$1.00 \text{ LBF} \cdot \frac{1 \text{ SLUG}}{32.174 \text{ LBF}} = \boxed{0.031 \text{ SLUG}}$$
$$1.00 \text{ LBF} \cdot \frac{1 \text{ KG}}{2.205 \text{ LBF}} = \boxed{0.454 \text{ KG}}$$
$$1.00 \text{ LBF} \cdot \frac{4.448 \text{ N}}{1 \text{ LBF}} = \boxed{4.448 \text{ N}}$$

1.92

GIVEN:

$D = 150\ mm$

$W_B = 2.25\ N$

$W_F = 35.4\ N$

$h = 200\ mm$

SOLUTION: CALCULATE SPECIFIC GRAVITY OF OIL

$$W_{OIL} = W_F - W_B = 35.4\ N - 2.25\ N = 33.15\ N$$

$$M_{OIL} = \frac{W_{OIL}}{g} = \frac{33.15\ N}{9.81\ m/s^2} = 3.3792\ KG$$

$$V_{OIL} = \frac{\pi}{4} D^2 \cdot h = \frac{\pi}{4}(0.15\ m)^2 \cdot 0.2\ m$$

$$= 0.003534\ m^3$$

$$\rho_{OIL} = \frac{M_{OIL}}{V_{OIL}} = \frac{3.3792\ KG}{0.003534\ m^3} = 956.20\ KG/m^3$$

$$SG_{OIL} = \frac{\rho_{OIL}}{\rho_{H_2O}} = \frac{956.20\ KG/m^3}{1000\ KG/m^3} = \boxed{0.9562}$$

1.107

GIVEN: $SG_{ALC} = 0.79$

SOLUTION: COMPUTE SPECIFIC GRAVITY TO SLUGS/FT³ AND G/CM³

$$\rho_{ALC} = SG_{ALC} \times 1000\ KG/m^3 = 0.79 \times 1000\ KG/m^3 = 790\ KG/m^3$$

CONVERT UNITS TO G/CM³:

$$\frac{790\ KG}{m^3}\left(\frac{1\ m^3}{1000000\ cm^3}\right)\left(\frac{1000\ G}{1\ KG}\right) = \boxed{0.79\ G/cm^3}$$

CONVERT UNITS TO SLUGS/FT³:

$$\frac{790\ KG}{m^3}\left(\frac{1\ SLUG/FT^3}{515.4\ KG/m^3}\right) = \boxed{1.533\ SLUGS/FT^3}$$

2.17

SOLUTION: 4 EXAMPLES OF NON-NEWTONIAN FLUIDS

PSEUDOPLASTIC, DILATANT FLUIDS, BINGHAM FLUIDS AND THIXOTROPIC FLUIDS

2.18

SOLUTION: VISCOSITY OF WATER AT 40° C

USING APPENDIX D, VISCOSITY OF WATER AT 40°C $\approx \boxed{6.7 \times 10^{-4}\ Pa \cdot s}$

2.27 VISCOSITY FOR HYDROGEN AT 40°F

SOLUTION:

USING APPENDIX D, VISCOSITY FOR HYDROGEN AT 40°F ≈ **1.8 x 10^-7 LB-S/FT^2**

2.35 VISCOSITY FOR SAE 30 OIL AT 210°F

SOLUTION:

USING APPENDIX D, VISCOSITY FOR SAE 30 OIL AT 210°F ≈ **2.3 x 10^-4 LB-S/FT^2**

2.61

GIVEN:
$D = 1.6$ MM
$SG_{OIL} = 0.94$
$\gamma_s = 77$ KN/M^3
$d = 250$ MM
$t = 10.4$ S

SOLUTION: VISCOSITY OF OIL

$$\rho_{OIL} = SG_{OIL} \times 1000 \text{ KG/M}^3 = 0.94 \times 1000 \text{ KG/M}^3 = 940 \text{ KG/M}^3$$

$$\rho_s = \frac{\gamma_s}{g} = \frac{77000 \text{ N/M}^3}{9.81 \text{ M/S}^2} = 7849.1 \text{ KG/M}^3$$

VELOCITY OF BALL:

$$v = d/t = 0.25 \text{ M} / 10.4 \text{ S} = 0.024 \text{ M/S}$$

$$\eta = \frac{(\rho_s - \rho_{OIL}) D^2 \times g}{18 v} = \frac{(7849.1 \text{ KG/M}^3 - 940 \text{ KG/M}^3)(0.0016 \text{ M}^2)(9.81 \text{ M/S}^2)}{18 \times 0.024 \text{ M/S}}$$

$$\therefore \boxed{\eta = 0.40165 \text{ Pa} \cdot \text{S}}$$